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Principles and Strategies for Designing Effective Computer-Mediated Instruction

ABSTRACT

Information professionals are increasingly asked to assist instructional designers or to be designers of computer-mediated information systems including the online instruction that facilitates their independent, skillful use by information consumers. This paper provides some guidelines for information professionals asked to create effective computer-mediated instruction. It begins with a discussion of a number of issues to consider both before and during the design process, describes a simple yet powerful instructional design model that forms a framework for making design decisions, and presents a wide range of design strategies for implementation.

INTRODUCTION

The overwhelming acceptance of computer technologies as instructional delivery systems requires designing instruction that considers the unique interactive capabilities of computers as a medium for providing effective, efficient, and appealing instruction to users. As more and more information services and resources go "online," information professionals are increasingly asked to assist instructional designers or to be the designers of computer-mediated information systems, including the online instruction that facilitates their independent, skillful use by information consumers.

Whether designing drill-and-practice programs in which the objective is the memory of simple skills, tutorials that teach concepts or rules, or simulations and games that integrate concepts, skills, and problem-solving activities (Bunderson, 1981), designers find a variety of creative options through computer-mediated instruction. This paper is intended to provide some guidelines for information professionals who are designing or adapting instructional programs or who are serving in an advisory capacity in that regard. It begins with a discussion of a number of issues to consider both before and during the design process, presents a simple yet powerful model that forms a framework for making design decisions, and concludes with a host of related design strategies to select based on specific needs and preferences. Figure 1 provides a graphic overview of the issues and model to be presented in this paper.

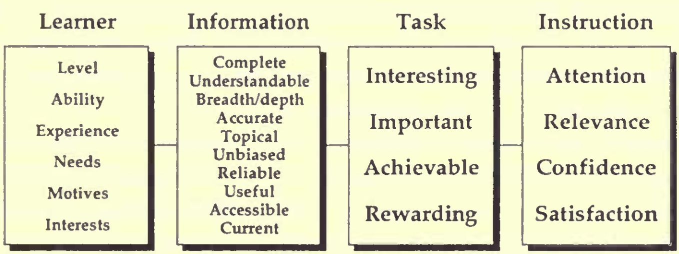

Figure 1. Design considerations for computer-mediated instruction

COMPUTER-MEDIATED INSTRUCTIONAL DESIGN ISSUES

Learners

The first issue to consider is always an information professional's primary concern—the users or, in this case, the learners. Who will receive the instruction? Who is the target audience? What do I know about them?

There are a number of important learner characteristics to consider before beginning the design process. When designing computer-mediated instruction, these characteristics become even more critical because the learning process is often an independent activity where the information professional or instructor serves in a facilitative or advisory capacity rather than as the source or provider of knowledge.

The level and ability of learners are important characteristics related to cognitive knowledge of the subject matter and psychomotor computer skills. Levels and abilities may range from remedial to gifted, from beginner to advanced, and from entry level to expert. In most cases, users of computer-mediated instruction represent a mixture of levels and abilities requiring a range of options to accommodate them. Other characteristics such as age and physical limitations may also affect the design of computer-mediated instruction.

In addition, learners approach the learning experience with a range of experiences both with the technology and the subject matter. If learners must possess specific entry behaviors or skills in order to successfully learn (e.g., English language skills, keyboarding skills, basic reading skills) and the computer program does not teach them, where and how will they get them? This is an additional consideration when planning computer-mediated instruction.

The second group of important learner characteristics relates to attitudes—both toward the subject matter and the technology. Attitudes encompass individual needs, motives, interests, and preferences. What do your users need or want to know or do?

There are several ways to determine learner characteristics, including reviewing the professional literature, consulting academic records, observing, testing, or interviewing. Although a careful analysis of the target learner population is recommended before beginning the design process, it is important to continuously evaluate the design with selected members of that population to be certain that it continues to be responsive to their needs and abilities (Marchionini, 1991).

Information

The second issue for consideration is the information itself. How do you judge the quality of the information (both the subject matter and the interface) for learning? This is often an overlooked dimension when designing instruction. If, for example, one designs a motivational, instructionally sound program in which the information is incomplete or inaccurate, that instruction becomes at best useless and at worst dangerous. For instance, if one is designing computer-mediated instruction that trains nuclear power plant workers to interpret online information, a change in the function of a key command that is not reflected in the instructional interface may result in learners becoming frustrated and not using the system. Furthermore, consider the potential consequences if the information itself is incorrect or out-of-date.

Taylor's (1986) Value-Added Model identifies a number of dimensions for evaluating the quality of information. In some cases, this type of evaluation may require consultation with a subject matter expert. The information may be evaluated on the following dimensions:

- *Complete.* Does the information provide comprehensive coverage of the topic for achieving predetermined learning goals?
- *Understandable.* Are the terms, language, and vocabulary used comprehensible to the intended users? Does it avoid unnecessary technical jargon and explain necessary complex or interrelated concepts?
- *Breadth/Depth.* Is enough information provided for learners to achieve predetermined learning goals?
- *Accurate.* Is the information error-free so learners can trust the system?
- *Topical.* Is all of the information directly related to the subject matter? Is there any peripheral or potentially distracting or irrelevant information that should be eliminated?
- *Unbiased.* Is issue-related information presented in a manner that includes more than one point of view?
- *Reliable.* Is there a consistent use of terms? Are the directions and rules consistent throughout the instruction?
- *Useful.* Is all of the information potentially useful to learners?
- *Accessible.* Are important content and instructions available at any time throughout the program?
- *Current.* Is the information the most recent and up-to-date required to attain predetermined learning goals?

Including a large amount of information allows the learner access based on individual needs, interests, or time available (Schaefermeyer, 1990). Winn (1990) suggests using task analysis and field testing procedures to determine the breadth and depth, completeness, and accuracy of the information.

Task

The third issue for consideration is the learning task. What are learners expected to know or do when they are done? Is the program functionality transparent or self-evident enough that learners can quickly turn their attention to the learning task rather than concentrating on how to use the program? For, what the task itself does not provide, the instruction must.

The first determination about the task is if it has intrinsic interest to learners. For example, it is probably unnecessary to spend much time designing strategies that motivate third graders to learn during a lesson on dinosaurs. On the other hand, it is unlikely that college freshmen find instruction on online searching equally intrinsically stimulating.

Another determination about the learning task is its importance to learners. If college freshmen must learn online searching techniques in order to complete a required history assignment, it is likely that the learning task will be important. If, however, online searching skills are taught isolated from any required or desired learning goal, the learning task may not be perceived as relating to learner needs or interests, and therefore the task does not, on its own, take on a sense of obvious importance to the learner.

A third task-related concern is whether the task is perceived as manageable or achievable by all learners. If learners lack the prerequisite skills or knowledge or if there are external constraints that prevent learners from successful achievement (e.g., not having enough time to complete the program), the task may be perceived as unattainable. Low self-esteem or feeling a lack of personal competence may also interfere with learning success. Finally, if the task is too complex or abstract for the target audience to comprehend, the likelihood of learning success will be greatly diminished unless prerequisite knowledge or skills are taught first.

The final task characteristic is whether accomplishing the task is, in and of itself, rewarding. What will learners gain from successful achievement? Most people need some type of reward for their efforts. Some rewards take a tangible form, such as grades or the proverbial "Christmas bonus." Other rewards are more intangible, for example, praise or when success at one level allows a learner to progress to a more advanced level. Although the ultimate goal of "learning for learning's sake" might be desirable, most learners require other types of rewards. Therefore, if the task is not perceived as intrinsically interesting, rewarding, and valuable, or if the task is complex and abstract, then specific instructional design strategies will need to be systematically included.

THE ARCS MODEL

Once the characteristics of the learner, the information, and the task have been identified, the design process may be initiated. Although there are a number of models that provide effective approaches to the systematic design of instruction, one model that is both powerful and easy to apply will be presented in this paper. The ARCS (Attention, Relevance, Confidence, Satisfaction) Model was developed by Dr. John M. Keller, Professor of Instructional Systems at Florida State University. The ARCS Model is based on a number of psychological theories, but its foundation is expectancy-value theory (Keller, 1983, 1987).

Most of the research on expectancy-value theory was conducted in the workplace to determine how to increase performance on the job. It is only within the past 15 years, through the work of Keller and others, that the theories developed for the workplace have been adapted to applications in education and training.

Therefore, in these latter contexts, expectancy-value theory may be described in the following manner—for learners to put forth the effort to reach a learning goal, they must (a) value the learning task and (b) believe that they can successfully accomplish the learning task. Both must be present. If either or both are absent, the likelihood of learner effort toward the task is low.

ARCS is a systematic approach to design that addresses both of these two criteria, as well as the issues previously described. There are a variety and range of design strategies that relate to each of the four ARCS principles. Although the ARCS Model may appear to be largely intuitive, its power lies in its organization and the ability to apply this intuitive knowledge.

As each of these strategies is described, it may be useful to reflect on computer-mediated instructional programs used in the past, whether they were effective or ineffective, and how the strategies presented in this paper might have improved or enhanced them. They may also suggest applications to meet current or future design needs.

Attention

The first ARCS principle is to gain the learner's attention and to sustain it throughout the instruction (Keller, 1987). To gain attention, consider that variety is "the spice of life." Variety can refer to multimedia formats selected on the basis of how best to represent the information. For example, if the information intends to convey motion, a sequence of events or time-lapse animation may be the appropriate strategy.

Format strategies that may be selected to provide this type of variety are

- text that includes expository information, examples, and practice items;
- graphics (illustrations, figures, diagrams, charts, maps);
- sound;
- animation;
- photographs;
- full-motion video.

There are other ways of providing variety. When a concept is complex or abstract, providing both a textual and visual representation offers useful redundancy of the concept to the learner because visuals convey ideas faster and easier than words, emphasize target information, and provide an alternative representation to satisfy visual learning styles (Hazen, 1985). Interspersing information presentation screens with interactive screens also provides variety (Keller & Suzuki, 1988). When information is varied with clear, familiar examples and performance activities and feedback, learners do not seem to tire of the activity as quickly (Dick & Carey, 1985).

Variety may also describe a number of attention-focusing techniques that are relatively easy to activate in computer-mediated instruction. These include

- *Flashing* (or blinking). This alerts the learner to important information or that some action is required.
- *Borders.* Borders can be used to set apart important information and draw the learner's eye to that information. They must be kept separate from the information they contain (Jones, 1988).
- *Colors.* They not only add aesthetic appeal but also may be used to facilitate readability or to indicate functionality. Color may also facilitate subtle discriminations within complex displays (Shneiderman, 1987). Colors should not be used in a way that contradicts common expectations (e.g., using red to indicate go forward and green to indicate exit) (Galitz, 1985).
- *Shapes.* They may be used to quickly indicate similar functional or navigational command keys or content areas (e.g., a text or graphics window). Both colors and shapes may be used to delineate areas on a screen, thereby helping the learner find needed information quickly and easily.
- *Highlighting.* This may be used to indicate important concepts or rules.

A number of other attention-focusing devices that draw the learner's attention to the most important aspects of the information have been identified (Carson & Curtis, 1991). These include

- type size or font and upper- and lowercase that may be used to emphasize or discriminate information;
- mnemonics and other memory devices that may be used to help organize information for long-term memory;
- humor, such as a well-placed cartoon (it must be noted that because humor is a subjective strategy—i.e., what one person finds humorous, another may not—it should be used judiciously);
- novel, surprising, or incongruous information that may attract learner interest and stimulate curiosity.

With all of these attention-focusing devices available to provide variety and enrich information, the designer may be tempted to infuse as many different strategies into the instruction as possible. However, although too few strategies may result in learning boredom, too many strategies may cause learning anxiety. The optimal number of design strategies is dependent on all of the issues discussed and, therefore, must be customized to the specified learning requirements. It is likely, however, that a design that specifies a menu with 20 flashing items, all in different colors and type fonts, will cause learning anxiety. Selection of attention strategies for variety must be purposeful, without sacrificing stability and structure. Designers should avoid dysfunctional attention-getting effects as they can be distracting and annoying (Keller & Suzuki, 1988). The use of too many attention strategies has been likened to driving down "The Strip" in Las Vegas—for many an assaulting rather than pleasing experience (Jones, 1988).

Furthermore, learners must have their attention refreshed throughout the instruction (Marchionini, 1991). That is, the strategies suggested above may be used to gain the learners' attention, but others must be implemented in order to sustain their attention thereby stimulating a deeper level of curiosity and higher level of interest throughout the instruction (Curtis & Carson, 1991).

An excellent method for sustaining attention is the inclusion of activities that require learner participation in the learning experience known as "interactivity"—a particularly relevant strategy for computer-mediated instruction. Interactivity maintains interest and involvement in the learning process. It may be accomplished through use of navigational and functional commands or keys in the interface and strategies such as practice items or embedded questions.

Two useful types of embedded questioning are "overt" and "subtle" questions. Overt questions typically require a verbal response, either by the learner typing it or selecting among a choice of responses. Subtle questioning does not necessarily require an immediate, physical response from the learner but is intended to promote active thinking by posing a problem that the learner must mentally ponder, generating alternative solutions as he proceeds through the program.

A third strategy for maintaining attention relates to making complex or abstract concepts more concrete. This may be accomplished by using examples of the concept, personal anecdotes, analogies, or visual representations.

Relevance

The second ARCS principle is concerned with helping the learner to understand the relevance of the learning task (Keller, 1987). Anyone who has worked with teenage children has probably heard occasional comments related to subjects such as algebra or earth science, "Why do I have to learn this? I'm never going to use it!" The importance of the learning task must be clearly articulated whenever it is not obvious to the learner.

One relevance strategy is providing familiarity—when learning about or doing something new is similar to something the learner already knows or does. This may be accomplished through the use of recognizable examples or anecdotes from the learner's realm of experience or by relating content to learners' prior experience or maintaining individual progress records within the program and referring to these at various points as the learner proceeds through the computer-mediated instruction (Keller & Suzuki, 1988).

Another method of providing familiarity is through the use of powerful metaphors or analogies to explain complex content making it easier to relate new ideas to those with which the learner is familiar (Curtis & Reigeluth, 1984). In a recent project to design multimedia case studies for learners enrolled in an international executive education program, the metaphor of a journey was used, and specific navigational tools strengthened the metaphor. For example, the menu was a "map," screens were organized into "regions," and individual screens had specific "locations" (Curtis & Gluck, 1992).

A second strategy for providing relevance is informing the learner of the purpose of the learning task at the very beginning of the instruction and reinforcing its usefulness throughout the instruction—that is, stating what the learner will know or be able to do after completing the instruction and linking achievement of the task to both learning goals and real-world applications. Game and simulation formats are useful for making somewhat obtuse subject matter seem more relevant.

Another relevance strategy is allowing learners to make choices that meet their individual needs and interests such as menus and submenus, varying amounts and sequences of accessible information, flexible entry and exit options, branching, on-screen notetaking capability, printing capability, "sound off" options, and full-screen or zooming capability. Options that include competitive or collaborative teamwork activities also allow further opportunities for meeting learner needs.

Confidence

The third ARCS principle considers ways to build learners' confidence levels (Keller, 1987). Instructional strategies that provide enough learning support for learners to succeed will help to build learning confidence, competence, self-esteem, the desire to persist at a learning task, and the motivation to continue learning.

Most learners tend to seek out challenging learning tasks as long as they believe they are attainable (McClelland, 1965). Most learners sincerely want to learn, to become competent at the learning task (White, 1959). Learning activities that seem either too easy or too difficult tend to be avoided because they are not perceived as linked to one's effort. When a task is perceived as too difficult to learners, it is unlikely that they will persist because the cost of success is seen as too high. Conversely, when a task is perceived as too easy to learners, it is unlikely that they will persist because it is seen as not worth the effort.

Specifying prerequisite skills, attitudes, and knowledge and clearly presenting the objectives and overall structure of the program at the beginning of the learning session allow learners to know whether they are adequately prepared to successfully complete the task (Keller & Suzuki, 1986). Providing feedback that links successful achievement with personal effort helps prevent perceptions that the results were due to luck or that the task was easy (Weiner, 1980). Novice computer users require more "user-friendly" programs and guidance than more expert users (Keller & Suzuki, 1988).

Confidence-building strategies provide both access to an appropriate level of difficulty and, when needed, to instructional aides such as pretesting and placement, accessible online help screens, and control over type and number of examples and practice items. In addition, orienting navigational headings and other cues that let learners know where they are, where they have been, and where they are going, as well as how long it will take, are desirable (Shneiderman, 1987).

To aid in learning, Carson and Curtis (1991) suggest the use of alternative, redundant representations of textual information (e.g., graphic overviews, diagrams, flowcharts), the use of divergent examples that proceed from simple to complex, matched nonexamples that are similar to the example and presented simultaneously to illustrate common errors, and embedded questions.

Although embedding overt questions within instruction offers a method for monitoring learning progress, in classroom settings instructors typically allow their students very little time to respond to those questions (usually no more than one second). Research indicates that providing slightly more time (3-5 seconds) results in a greatly increased likelihood of student responses (Rowe, 1986). Yet instructors seem to feel uncomfortable with silence and often blurt out an answer to avoid it. Although the response may be in the instructor's short-term memory (on the "memory surface") because the instructor has been thinking about it, it is likely to be in the learner's long-term memory, thereby requiring additional time for the learner to retrieve the information. Computer-mediated instruction is especially "patient" in providing the appropriate amount of wait-time, based on the learner's required or preferred pace, which permits the learner to retrieve relevant information from long-term memory, organize that information, and respond to the question posed—greatly increasing the opportunity for a successful response.

Some additional useful strategies that help to build learning confidence are

- graphic overviews that provide the learner with a context for organizing information;
- chunking textual information into short, meaningful, and manageable segments (Keller & Suzuki, 1988) according to the age level of learners, complexity of material, type of learning taking place, flexibility of the activity, and learning time requirements (Dick & Carey, 1985);
- scheduled synthesizers that relate ideas within or across lessons and integrate new material with old and summaries that follow presentation of significant chunks of information throughout the instruction, reviewing what has been learned (Reigeluth & Stein, 1983);
- divergent examples and content that range from easy to difficult, known to unknown, and simple to complex;
- learning cues or prompts that can "jog" the learner's memory (Cohen, 1983);
- menus so that learners do not have to recall or type terms or phrases in order to access needed information; and
- more explanation or guidance for those with little or no previous knowledge of the topic and a fast track for those who wish to move quickly through the instruction.

Galitz (1985) recommends a number of confidence-building strategies including recovery options for retracting or undoing an action, commands that use familiar, obvious, or common commands, function keys for frequent actions (e.g., page forward), and labels that provide information that clearly describes a function key's purpose. Providing supplementary print materials such as quick reference cards, manuals, job aids, and keyboard templates allow learners to choose alternative formats that best match their learning styles and preferences (Cohen, 1983).

Consistency, another confidence-building strategy, may be implemented by setting consistent standards for achievement that are fully and adequately described to the learner at the beginning of the instruction and reinforced by the way the information is presented and learning is evaluated. For example, instruction that requires the learner to recall or recognize information would be presented and evaluated differently than instruction that requires the learner to apply newly learned information to a new situation (Carson & Curtis, 1991).

Consistency may also be provided through logical organization of content and use of color, shapes, terms, and key functions, which aid in screen location. Consistent screen designs that have an orderly, well-spaced, clutter-free, and clean appearance, and transparent functions; that use plain, simple English, large enough fonts to read easily, and clear labeling; and that cohesively group relevant elements on a screen help to cue appropriate cognitive behavior (Schaefermeyer, 1990; Hannafin & Hooper, 1989; Hooper & Hannafin, 1988; Jones, 1988; Galitz, 1985). An instructional interface that provides consistent selection methods, window layout, and positioning of important text and buttons is also desirable. Consistent location, structure, and terminology should be preserved, with only occasional variations (Shneiderman, 1987; Keller & Suzuki, 1988).

Another strategy for building confidence is feedback. Duffield (1991) defines the three basic steps in human-computer interactions as (a) the computer receives a response, (b) the computer processes the response, and (c) the computer provides feedback to the learner. Feedback can also be used as guidance when the learner uses inaccurate or inappropriate strategies, immediately following response to a question or completion of a practice item.

Reinforcing feedback is useful to encourage and support learning as long as it is used sparingly and is always linked to effort. The most effective type of feedback is corrective feedback that presents a message immediately after the learner has made an error. Corrective feedback not only provides the learner with a simple, concise, and nonthreatening error response and directs the learner to the error, but also includes the steps involved in the correct solution (Wager, Wager, & Duffield, 1989; Cohen, 1983; Tosti, 1978). In this way, the feedback becomes part of the learning experience.

Satisfaction

The final ARCS principle promotes learning satisfaction (Keller, 1987). One method for doing so is to show or explain the consequences of successfully achieving the learning task; for example, pointing out that the learner can now do something she was unable to do previously, understand something new and difficult, or use something in a new way.

Extrinsic rewards used in computer-mediated instruction such as motivational feedback linked to effort may take the form of animated sequences, sound effects, or verbal praise. These are useful as long as learners have control over receiving feedback and opting out of it (Keller & Suzuki, 1988). Although some tasks require extrinsic rewards to motivate learners, the ultimate goal of instruction is to develop an intrinsic motivation to learn.

Another way to link learning to its consequences is by providing opportunities for learners to use their newly learned knowledge or skills in real or simulated, meaningful applications (Keller & Suzuki, 1988). Opportunities to immediately apply what is learned to a real problem such as a class assignment or job responsibility promote learning satisfaction. As new instructional technologies such as multimedia and virtual reality develop, learners will be exposed to exciting new ways of simulating life experiences that are either too difficult, too expensive, or too dangerous to experience in reality.

Another strategy for promoting learning satisfaction is by providing an environment of "learner control" in which the learner perceives a sense of learning empowerment over the learning experience. Computer-mediated instruction lends itself extremely well to developing this sense of learner empowerment by allowing, to a greater or lesser degree, control over the pace of the presentation, the sequence of content, and options such as returning to a desired screen or module, choosing when and where to enter and exit the program, reentering where the learner left off, selecting additional examples or practice items, saving completed work, printing completed work, or deciding which information to engage and which to ignore or bypass. However, the amount of learner control provided must be carefully determined based on the various design issues presented in this paper. Research indicates that learner control does not assure greater learning (Steinberg, 1989) and may, in fact, result in an unintentional lack of access to critical information. This is an important consideration when making decisions regarding learner control.

A final strategy for promoting learning satisfaction is through equity. Equity assures that the goals and evaluation criteria for learning set and stated at the beginning of the instruction are the same at completion of the instruction, that the instruction does what it was purported to do, and that the objectives, content, and test items are consistent so that learning success is attributable to the effort the learner has put into the learning activity (Curtis & Carson, 1991).

CONCLUSION

This paper has outlined several learning inputs to consider in the design of effective computer-mediated instruction. Issues to consider are learner characteristics, quality of information, and task characteristics. The ARCS Model, in consideration of these issues, proposes four design principles and a variety of related strategies for the creation of effective, efficient, and appealing computer-mediated instruction. The resulting outcomes are improved learning performance and increased motivation to learn.

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